SPECIES OF EMERGENCE

by Gregory R. Peterson

Abstract. The category of emergence has come to be of considerable importance to the science-and-religion dialogue. It has become clear that the term is used in different ways by different authors, with important implications. In this article I examine the criteria used to state that something is emergent and the different interpretations of those criteria. In particular, I argue similarly to Philip Clayton that there are three broad ranges of interpretation of emergence: reductive, nonreductive, and radical. Although all three criteria have their place, I suggest that the category of radical emergence is important both for science and theology.

Keywords: emergence; nonreductive physicalism; reductionism; supervenience; top-down causation.

Emergence has become a central and almost necessary category for many theologians engaged with the sciences. One does not have to go very far to understand why. To claim that there are emergent realities is to counter reductionistic interpretations of science that are inherently hostile to theological categories. Theories of emergence provide a framework that makes scientific and theological claims compatible, even to the point of allowing the two to be yoked together into a single synthesis. Small wonder, then, that many of the most prominent theologians and philosophers within the theology-science dialogue have invoked theories of emergence to varying degrees.

At the same time, views as to what exactly constitutes genuine emergence vary quite widely. Although the phrase "the whole is more than the sum of its parts" is frequently invoked, it is taken to mean different things by different scholars. Correspondingly, my goal in this essay is twofold: first, to categorize the primary senses of emergence as they occur in relevant

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fields of philosophy, theology, and science; and, second, to suggest how these different senses may be found useful for the ongoing theology-science dialogue. Although it is tempting to argue that only one sense of emergence is the correct one, the more accurate observation is that different senses of emergence have their place and value. The primary difficulty is understanding which sense of emergence is appropriate to describe which kind of phenomena.

WHY EMERGENCE?

All of philosophy, Alfred North Whitehead once observed with only mild hyperbole, is a footnote to Plato. It is a claim that is at least partially true of emergence theories. Plato and his contemporaries struggled with the question of the one and the many, and Plato's famous solution was to divide the world in two, between the ever-changing material world and the everlasting world of forms. The solution was a problematic one, and later generations modified Plato's doctrine of forms accordingly. Aristotle spoke of formal causes; later neo-Platonists divided the two worlds into one world with many layers, a great chain of being that provided a hierarchy of both being and value. Although medieval scholars battled over the issue for centuries, the more skeptical nominalist view eventually won out, influencing the development and tenor of the scientific revolution.

Most analyses of emergence do not begin with Plato, but I emphasize this connection at the outset for two reasons. First, at least one form of emergence claims appeal to a kind of Platonic argument, and it is important to recognize this in order to understand the complexity of the issues that emergence theories present. Second, the historical rejection of Platonism within the sciences (and those early philosophers and theologians influenced by the sciences) is arguably at the root of the impetus for the development of emergence claims to begin with.

The rise of emergence theories, beginning in particular with the works of the British emergentists (Morgan 1923; Broad 1929), can be seen precisely in light of a rejection of a reductionism that denied the reality and relevance of higher-order principles and realities. The emphasis on mechanism placed the primary reality at the level of the most basic material constituents. For reductionists, the result was a worldview that ultimately denies the reality of any higher-order pattern or entity, including the mind and ethical values.

The British emergentists provided the initial impetus for a rejection of reductionism that was consistent with the sciences. Later discourse on emergence has proceeded along two different but linked lines of thought. Emergence claims are most associated currently with the philosophy of mind and the status of the mind in relation to the body. Simply put, if both traditional dualism and materialism are false, there must be a sense in which the mind is still real even though it is in some sense dependent on the body. Theories of emergence and its linked concept, supervenience, provided one way to account for this reality. Similar issues arose for the philosophy of biology in the middle part of the twentieth century, for, if pure reductionism is true, what can one make of the complexity and novelty of biological organisms and the laws that govern them? Emergence thus became a way to speak of any kind of higher-order reality, so much so that one could reconstruct a new kind of hierarchy of being composed of the different levels of analysis that each scientific discipline represents.

In this vein, it is noteworthy that several of the early works that began the modern phase of discourse on emergence and reduction were significantly interdisciplinary in character, involving both scientists and philosophers (Koestler and Smythies 1969; Ayala and Dobzhansky 1974; Globus, Maxwell, and Savodink 1976). Indeed, emergence can be used as a general category for understanding the physical world and not simply as a category for explaining biological organisms. Physical phenomena such as the Pauli exclusion principle, higher-order forms of physical complexity, and even the properties of water as distinct from its molecular constituents have been cited as examples of emergence (see Morowitz 2002).

For emergentists, the issues are twofold. In much of the literature, the primary issue is an ontological one; there is a sense in which minds, complex wholes, and the laws that govern them can be said to be real even when composed of lower-level material objects. Thus, a scientifically informed worldview and an ontologically reductionist worldview are not the same thing and, on some accounts, are even opposed to each another. Therefore, it is possible to believe that minds are real while simultaneously subscribing to the truths found in neuroscience and to believe that cells and the laws of evolution that govern them are real while simultaneously subscribing to the laws of physics and chemistry.

Second, higher-order wholes not only are real; they also are causally efficacious. This is particularly important for the philosophy of mind, where issues of human freedom and mental causation are primary. A mind that is real but is a passive observer (that is, epiphenomenal) is a possibility, but a not very palatable one. The issue of causation is more important for some accounts of emergence than for others, as we shall see.

Finally, it is worth mentioning here what is at stake (or perceived to be so) for theology. Theologies that are strongly dualistic at the outset (both with regard to human nature and with regard to the God-world relation) have, arguably, little at stake in theories of emergence. Because mind and God are completely outside the sphere of nature, emergence plays no role for such thinkers. Rather, the primary problem is one of reconciling such a dualism with science at all. Emergence is a primary issue for theologians who reject traditional dualisms and, consequently, feel strongly compelled to reject traditional reductionisms as well. It may be argued that this involves almost all theologians involved in the theology-science dialogue.

Doctrines of redemption make sense only if there is someone to be redeemed. Furthermore, if God is not completely separate and transcendent over the world (as maintained by panentheists), the arguments concerning emergence have possibly some bearing on the doctrine of God itself.

CHARACTERISTIC FEATURES OF EMERGENCE

What does it mean for something to be emergent? Consider the following three quotes:

> Now it is true that the answer to "What else is there (other than atoms and molecules) in, say, a living organism?" is "no-thing at all", but this does not mean that describing its molecular constituents and their properties is all there is to be said, that there is nothing more to be said by way of description of the individuality of a particular living organism, especially if it is a human one. (Peacocke 1993, 40–41)

> Systems at each hierarchal level have two properties. They act as wholes (as though they were a homogeneous entity), and their characteristics cannot be deduced (even in theory) from the most complete knowledge of the components, taken separately or in other combinations. In other words, when such a system is assembled from its components, new characteristics of the whole emerge that could not have been predicted from a knowledge of the constituents. (Mayr 1988, 15)

> Emergences thus occur both in model systems and in real world situations. If the models are well chosen, the two kinds of emergences map onto each other. They resonate with each other. In both cases, emergence leads to novelties: the whole is somehow different from the sum of the parts. (Morowitz 2002, 20)

I select these three passages, not quite at random, to illustrate some of the common threads of what emergence is taken to mean as well as the widespread usage of the term. There are certain concepts (and slogans) that are core to what emergence is about. At the same time, there is some diversity as to what constitutes this core and what exactly these core concepts and slogans imply. I suggest that, for emergentist positions to be coherent, seven elements generally taken to be central claims of the emergentist position need to be explored and enunciated carefully.

One requirement of an emergent entity is that it be capable of some kind of *higher-order description*; there is some kind of whole to be analyzed. Depending on the emergentist in question, the higher-order description may be just about anything. On some accounts, even an individual rock or properties such as the wetness of water may be taken to be emergent (see, for example, Allen and Bekoff 1997, 8). More common, however, is the claim that emergent entities be understood in some sense as functional wholes. Thus, any living organism may be taken as an emergent whole. So too may basic elements (because they reveal a structural organization), complex ecosystems, or artifacts such as computers.

Once the wholes have been identified, it is typically claimed that these wholes obey various sorts of *higher-order laws*. Stuart Kaufmann (1995), for instance, describes life as an emergent phenomenon that can then be understood to obey certain laws of self-organization and complexity. Much has been made of John Conway's Life game, which stipulates a world composed of discrete pixels that have two states, either on or off, whose states are controlled by a simple set of rules. What is interesting about the game is that the simple rules that govern the pixels individually give rise to recognizable higher-order "organisms" that persist and even move across the computer screen; these higher-order organisms, in turn, obey certain kinds of regularities, or laws, so that their behavior can be described independently of the lower-level "physics" of the life world. Both the entities and the laws that govern them might be said to be emergent. (For a description with relevance to these issues, see Dennett 2003; Sharpe and Walgate 2003.) Similarly, higher-order regularities and principles such as the laws of evolution, psychology, and economics can be said to also be emergent, governing the behavior of the relevant higher-order entities already described. Although the idea of higher-order laws and higher-order description are conceptually distinct, they are typically seen as going hand in hand.

Claims of higher-order description and higher-order laws typically lead to a third claim, that of *unpredictable novelty*. This point is made explicit in the already cited quotes from Ernst Mayr and Harold Morowitz. The novelty in question takes one of two forms. The last sentence of Mayr's quote ("In other words, when such a system is assembled from its components, new characteristics of the whole emerge that could not have been predicted from a knowledge of the constituents") implies an organizational novelty. That is, the higher-order whole could not have been predicted from an analysis of the parts independently. Morowitz, by contrast, seems to take an historical approach to novelty; what makes something emergent is (in part) our inability to predict its occurrence beforehand. Presumably, both kinds of novelty can exist side by side (perhaps necessarily so). In either case, novelty is taken to be the opposite of predictability; what makes an object or law emergent is, in part, the unpredictability of that object or law in advance.

To have wholes, however, one must have parts, and it is in the characterization of wholes and parts that emergentist theories achieve their primary distinctiveness. First, emergence positions imply that *parts are necessary for the existence of the whole*. There is a part-whole relationship that is essential to understanding something as emergent, and without the parts the whole cannot exist. This is particularly clear in the quote from Arthur Peacocke. It is this claim that most centrally distinguishes emergentist positions from dualist ones. In René Descartes' understanding of the relationship of the mind and body, the mind is not dependent on the body and can exist independently of it. This contrasts significantly with an emergentist position, which would imply that if there is no body, there can be no mind.

Second, and equally important, emergentist positions argue that *the parts* *are not sufficient for the whole*. Thus, after claiming that there is "no-thing" above the parts, Peacocke also maintains that this "does not mean that describing its molecular constituents and their properties is all there is to be said, that there is nothing more to be said by way of description of the individuality of a particular living organism, especially if it is a human one." While the claim of necessity opposes the emergentist position to dualism, the claim of insufficiency contrasts emergentism with reductionism. Thus, in a famous example, Donald Campbell argues that it is insufficient to understand a soldier termite's jaws solely in terms of its molecular constituents. To understand the termite jaws fully, one must also have an understanding of the emergent properties of the functional organization of the termite, its role in the termite society, and the laws of evolution that shaped that society as a whole (Campbell 1974).

These five elements may be enough to distinguish emergence as a position, at least in an ontological sense. It is typical, however, to add one or two other claims. For most emergentists, it usually is not enough to say that emergent entities exist; it also is important to claim that they are *causally efficacious*. Thus, emergent entities are said to employ a top-down causality, in contrast to the bottom-up causality of its constituent parts. In his example of the soldier termites, Campbell argues for a top-down causal role of evolutionary laws. The notion of top-down causality is especially central to emergentist theories of mind, for this allows the mind not only to exist but also to have a causal influence. This causal influence is typically understood as a constraint of the whole on the action of the parts. Peacocke (1999) also speaks of top-down causation as downward flow of information. Either way, the claim is that higher levels play a central role in explaining why things happen.

Finally, but somewhat less frequently, emergent entities may be said to be *multiply realizable*. This may be seen as a consequent of the joint claims of necessity and insufficiency but also comes centrally out of the history of thinking about the philosophy of mind. For example, two individuals may have identical experiences of pain despite having differing configurations of neurons. An extraterrestrial would (presumably) have a different kind of brain but still be capable of thinking the same thoughts about mathematics as human beings do. First elaborated by Hilary Putnam, multiple realizability has played an important role in the philosophy of mind as a way of conceiving of the mind as not simply identical to the brain and therefore, in some sense, an independent reality (Putnam 1960; for a summary, see Bickle 2002). Multiple realizability, among other qualities, is what seems to give emergent entities a nonreductive character, because there is no one set of physical things that they are said to be identified with.

When we speak of emergence, then, it seems that we are speaking of seven interrelated characteristics:

1. Emergent entities are characterized by higher-order descriptions.
2. Emergent entities obey higher-order laws.
3. Emergent entities are characterized by unpredictable novelty.
4. Emergent entities are necessarily composed of lower-level entities.
5. Lower-level entities are insufficient for emergent entities.
6. Some emergent entities are capable of top-down causation.
7. Emergent entities are characterized by multiple realizability.

On any given account of emergence, many if not all of these claims are included. Of the three authors cited above (Peacocke, Mayr, and Morowitz), all seem likely to include the first six features in their understanding of emergence, and perhaps the seventh as well. Philip Clayton (2004) has provided a similar listing that captures many of these features. Beyond this, however, that commonality in the characterization of emergence ends. Instead, we find a great deal of diversity of interpretation, often using the same or similar arguments and examples but coming to widely variant conclusions.

CENTRAL ISSUES: EXPLANATION, CAUSATION, AND ONTOLOGY

Among emergentists there is widespread agreement on the explanatory significance of emergent entities. One reason that purely reductionist approaches are much criticized is because they seem to leave out so much, that in emphasizing the individual trees one misses the significance of the forest. Using Campbell's example of the soldier termite's jaw, to explain the jaw in terms of its molecular constituents is to explain nothing. To do so loses the understanding of the jaw's function as well as the relation of the soldier termite to the termite colony as a whole and the relation of the termite colony to its evolutionary history. To understand the termite's jaw, it is not enough to understand its molecular constituents. One must understand the jaw as an emergent whole, which in turn is part of larger, emergent wholes, the colony and its evolutionary history guided by laws of natural selection.

Arguments of this sort abound and are used to hammer at a naive reductionism that understands every object solely in terms of its parts, employed even by scientists in order to make sense of the phenomena that they are describing. Stephen Jay Gould has famously argued for multilevel or hierarchical account selection theory to more fully explain the evolutionary process, as have Elliot Sober and David Sloan Wilson in a different context (Gould 2002; Sober and Wilson 1998). Paul Glimcher (2003) has argued that in order to understand why individual neurons behave the way they do we need to employ a higher order of explanation, looking not only at the individual neurons but at the kind of problems that the organism as a whole is trying to solve. Examples such as these abound in science writing and indicate the important functional role that speaking of higher-order entities plays in the practice of many scientific disciplines.

Speaking of emergent entities, therefore, is important not only for interpreting science but also for the practice of science. To understand complex entities, it is not enough to understand the parts of which an entity is composed. The concept of emergence is therefore essential to the process of understanding. What is not clear, however, is the ontology implied by these various claims. Are emergent entities real, or are they simply useful fictions?

One immediate problem we find is that of terminology. Note Peacocke's insistence that there is, properly speaking, no-thing at all above the material constituents of an organism, implying that there is no extra substance, no *élan vital*, that is at work and that is separate from the individual parts. That would be the path of dualism, which emergentists disavow. But if emergent entities are not independent substances, what are they? In the philosophical literature, they are frequently described as properties or, in specific cases, emergent laws or events. But what is an emergent property?

At this point we find the shadow of Platonism looming large, for it seems that we have primarily two options. The first option is to understand emergent entities as useful fictions. We can call this the nominalist view. Nominalist William of Ockham argued that Platonic forms are mere names with no further reality or, at best, concepts or conceptual relations that exist only in the perceiving mind. Likewise, when one speaks of emergent laws such as the law of supply and demand or of emergent entities like a cell or a computer program, the nominalist would say that these are nothing more than useful fictions—useful because we are middle-sized creatures who perceive the world in a particular way. Because our eyes have limited resolution, we see the table (or the rabbit) as a whole and give it a name as a consequence; if our visual resolution was sufficiently higher, we would not see the table at all but just a collection of atoms. On the nominalist view, we speak of tables, cells, and economic laws because such orderings of our experience are useful, not because they are real. To invoke emergent entities because of their explanatory power, then, is to simply acknowledge their explanatory usefulness. We speak of panda bears because it is useful for us, as middle-sized beings with modest visual resolution, to do so. But ontologically, any individual panda bear is a collection of subatomic particles, and pandas as a species concept is, presumably, a set of such particle arrangements.

Although this is a possible interpretation of emergence, most who invoke the language of emergence seem to argue otherwise. For most emergentists, there is an important sense in which pandas, people, and laws of economics are real that is more than stipulating them as a mere aggregation of their respective parts. Emergentists generally abhor statements that include the phrase "nothing but" in them, such as "a panda bear is nothing but a collection of molecules." So, the emergentist is saying that there is, ontologically, something more to these emergent realities. What is this something more?

This question of the ontology of emergent entities typically is linked to the question of the causal efficacy. As already noted, a central claim of emergentist positions is that emergent entities are capable of exerting a kind of top-down causation. Neuroscientist Roger Sperry was one major proponent of this view, arguing that any complete account of human action must not only take into account the flow of causality from neurons to brain to mind but must also conceive of the top-down causal effect of the mind on the brain (Sperry 1987).

The prime question, however, has been exactly what is meant by top-down causation. Normally, the idea of top-down causation is meant not to replace or contradict the causal powers (usually understood in terms of Aristotle's efficient causation) of the lower levels of physics and chemistry but rather to complement them. In explaining why a particular neuron fires, for instance, we can give an explanation in terms of bottom-up causation, enumerating the individual molecules of which the neuron is composed, the laws that govern the individual particles, and the immediately antecedent conditions that lead them to act as they do. But, observes the emergentist, we have explained very little by making these observations, because we have not, in a larger sense, understood why the neuron is firing, which is because it is connected to a broader visual network in the brain that is responsive to my higher-order decision to turn and look at the clock. For the emergentist, bottom-up causation is always part of the story, but when it comes to complex objects, it is only part of the story.

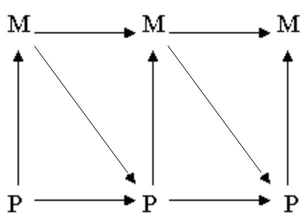
Frequently, notions of top-down causation hinge on claims about relevant boundary conditions. Emergent entities provide the context in which local, bottom-up causation takes place and is made possible. To refer back to Campbell's soldier termite, a bottom-up causal account of how the termite's jaw came to be would rely simply on the molecular constituents, the relevant physical laws, and their antecedent conditions. But such an account does not tell us why the molecules work together to form a jaw to begin with. To understand that, we need to invoke the top-down causal powers—the boundary conditions imposed by DNA encoding, cellular organization, niche and colony specialization, on up to the laws of natural selection. Similarly, in order to understand a computer network, it is not sufficient to understand it as a linear sum of its parts; one must understand a network as a higher-order whole that exerts a downward causal effect on its individual components.

As in the case of ontology, there is a key link in many arguments regarding top-down causation to claims about understanding and explanation. Top-down causation is important because it is essential in order for us to understand what is going on in many complex physical systems. It is, one might say, psychologically necessary. But is top-down causation real?

As with the ontological question, we can go two routes. We might describe top-down causation as a useful fiction. That is, top-down causal language is important because it helps us middle-sized beings of limited cognitive capacity understand physical systems that would otherwise be beyond our comprehension. We cannot see the molecular constituents of the soldier termite's jaw, let alone envision all the molecular constituents that make up its environment and that environment's past evolutionary history. Concepts such as *cells*, *ant colony*, and *natural selection* and the causal claims associated with them are useful approximations for the biological sciences, but they are only approximations and, in the end, simply fictions that help us in our tasks as scientists and philosophers.

Along this line of thought, it is worthwhile to point out how careful many emergentists are in claiming that emergent entities and their top-down causal effects do not imply a negation of lower-level efficient causation. This leads to some fuzziness in exactly how to construe what a top-down cause is. Peacocke, for instance, speaks of top-down causation as a "flow of information" (1999, 225–26). Philosopher of mind Fred Dretske (1997) distinguishes between triggering causes and structuring causes. In these and other cases, it is unclear to what extent we should really regard top-down causation as a cause in the normal way we use the term or if something else entirely is meant. If top-down causation is really a flow of information, perhaps emergentists should abandon the language of causality altogether in order to avoid confusion.

Many of those who have taken the idea of top-down causation more literally have argued in favor of a supervenience relation between lower-level and higher-level properties that would allow for a robust understanding of top-down causation. Within the science-and-theology dialogue, Nancey Murphy (1999) has been one of the most vocal supporters of this account. Generally speaking, supervenience accounts of top-down causation assume a (largely) deterministic and complete lower-level framework out of which arise supervenient, emergent properties that in turn exert a downward causal effect on the lower-level, subvenient elements. In the specific case of the mind-body relationship, one may speak of a causal relation not only from the physical to the mental but also from the mental back to the physical. A typical diagram envisions the relationship this way:



But does the mental really play a causal role here? There is good reason to suppose that it does not (Kim 2000). As long as a physical system is deterministic and nonchaotic (a big "if" to which we will return), it should in principle be possible to determine the behavior of the system, however large and however bounded, in terms of its most basic constituents alone without invoking the top-down causal role of emergent entities. It may be said that in doing so we do not sufficiently understand the system in question. We have missed out, perhaps, on the interesting higher-order regularities of natural selection, but the critic may with some safety dismiss that as a merely psychological matter. If I can accurately model and predict how a system operates, I have all the understanding that I need.

There may be room for rejoinder here, but it would seem that supervenience is of limited use for the emergentist who endorses a robust notion of top-down causation. If so, the emergentist has to look for an alternative to strict supervenience or give up on the causal effects of emergent entities. If the latter, emergent entities might be real but epiphenomenal, with the result that emergent entities have no causal impact whatsoever. Most emergentists would regard this as a disaster.

Species of Emergence

At this point, we can observe that not all emergentists endorse supervenience as a way to account for top-down causation. Indeed, once we get beyond the primary seven characteristics that most emergentists have in common, we find considerable diversity as to how to regard the more specific ontological and causal claims. This diversity is tied fairly strongly to other, prior, ontological commitments regarding the physical world. With regard to such commitments, we may construe views of emergence as ranging from the more conservative to the more liberal. Although each different approach to emergence has its place, I suggest that if emergence is going to have the kind of interesting implications that many of its advocates claim, it is the more liberal accounts that will have to be endorsed.

Reductive Emergence. On the most conservative account, emergent entities and their causal forces are nothing more than useful fictions. This is the nominalist view alluded to above, and when it is endorsed it usually is accompanied by a strong commitment to reductive physicalism. Biologist Richard Dawkins and philosopher Daniel Dennett may both be seen as exemplars of this kind of view. In his book *The Blind Watchmaker* (1996) Dawkins briefly addresses the issue of reductionism, explaining that he rejects a naive reductionism and endorses what he calls hierarchical reductionism, which accepts the usefulness of higher-order descriptions and explanations. Similarly, Dennett distinguishes between good reductionism and greedy reductionism. Good reductionism acknowledges that objects can be described in different ways and in terms of different hierarchical levels. Indeed, Dennett argues that for some objects (such as most animals and sophisticated robots), we can take three stances—the physical stance, the design stance, and the intentional stance—each with different kinds of explanation associated with them (Dennett 1987; 1995).

Most emergentists will likely counter that neither Dawkins nor Dennett is a genuine emergentist; they are reductionists, the very opposite of what emergentism is about. In an important sense they are right. For both Dawkins and Dennett, there is a strong sense that the whole is nothing more than the sum of its parts and that emergent level entities and explanations are simply useful fictions that aid in our understanding of how things work. Dennett, for instance, sometimes makes this point elliptically, as when he refers to the theory of natural selection as a universal acid, but he also explicitly refers to higher-order entities as useful fictions in other places (Dennett 1990). Yet, both Dennett and Dawkins are willing to use such emergent language as a tool for explaining the complexity that surrounds us, and this contrasts with some schools of thought that would deny even this much—for example, the agenda of eliminative materialists that wanted to completely replace what they dubbed "folk psychology" with the language of neuroscience (see Churchland 1986). As such, Dennett and Dawkins represent one logical if largely unpalatable end of dealing with emergent entities short of a complete eliminativism.

This sort of view seems at least partially endorsed more recently by Donald Wacome (2004).[1] Wacome argues that the concept of pizza is not simply reducible to material components. Pizzaness is multiply realizable in the sense that there are many (perhaps infinitely many) kinds of pizza. Nevertheless, Wacome observes, we generally do not feel compelled to endorse pizza dualism. Pizza is, Wacome claims, nothing more than its physical constituents. In other words, pizza as a term and concept is useful, but that does not make pizzaness real in any relevant sense. Pizzaness is a useful fiction.

Nonreductive Physicalist Emergence. To many, a more satisfactory approach is to endorse emergence within the context of a nonreductive physicalism. Generally speaking, nonreductive physicalists agree with other physicalists that at the lowest level of analysis everything is physical and everything is composed of physical particles (such as quarks and electrons) and the laws that govern them. For the nonreductive physicalist, however, emergent entities are both real and causally efficacious. Most important, this provides room to speak of mind, spirit, and freedom in a way that is not available to the simply nominalist approach to emergent entities. On a nominalist approach, mind, spirit, and freedom are simply useful fictions. The nonreductive physicalist claims something more: mind, spirit, and freedom are real by virtue of being irreducible, and, being real, they have causal impact.

Centrally assumed in most accounts of nonreductive physicalism is the notion that scientific accounts of nature are essentially accurate and complete enough in such a way that new scientific discoveries are not going to result in any major changes of how things work, particularly with regard to biological organisms. Although there is much that is undiscovered, the nonreductive physicalist generally is confident that new developments in string theory (for instance) are not going to affect how we think about the relationship of mind and brain, and that although new discoveries in neuroscience will doubtlessly be important, they will not alter the basic logical relations between the brain as a physical phenomenon and the mind as an emergent entity or set of properties that emerge from the brain. Because of this emphasis on the closure of the physical, I have elsewhere referred to emergence within a nonreductive physicalist position as closed-system emergence (Peterson 2002). As such, the nonreductive physicalist acknowledges the necessity of a physical substratum for the existence of emergent entities but emphasizes in particular the insufficiency of the physical to properly account for the emergent entities and the relations between them. There is an explanatory gap.

Given this gap, we can put the question this way: If nonreductive physicalism is true, what kind of emergence is possible? Taking the ontology claim first, we might ask what it is that makes a human mind real and not simply reducible to the brain and its actions. One option is to define the reality of emergent entities simply in terms of the seven criteria noted earlier. That is, something is said to be real simply by virtue of higher-order description, insufficient lower-level conditions, and so on. In particular, the claim to the insufficiency of the physical substratum is key, because it suggests that there is something more to the emergent entity than simply its lower-level physical components. Multiple realizability is seen as buttressing this point. In the case of the mind-body relation, although each individual brain is different in minute and sometimes important ways, nevertheless different brains can realize the same experiences (the sensation of rough sand on the skin) and thoughts (knowledge of the Pythagorean theorem). In principle, this could be true even among brains that are radically different. If intelligent aliens landed on the planet tomorrow, by virtue of their intelligence they too would be able to understand the Pythagorean theorem, but they would presumably have brains very different from ours. Similarly, computers with different physical configurations and operating systems (PC, Macintosh, Unix) may differ in terms of the physical states yet still produce the same emergent state, for example, a Web page running a Java applet (a small program written in the Java programming language). Indeed, we may say that the Java applet running on each machine is identical, even though the physical procedures involved in running the applet on each computer is different.

This assertion of the reality of emergent entities may still seem troublingly vague to some. If emergent entities are not simply identical to their physical constituents, what are they? For nonreductive physicalists, the reality of emergent entities cannot come from some other supernatural realm, because then they would no longer be nonreductive physicalists; they would be dualists of the standard Cartesian variety. Nor can nonreductive physicalists claim that there is some unknown but relevant physical quantity that stands unaccounted, because they have previously claimed that we know pretty much all there is to know about the physical and that anything new that is yet to be discovered promises not to affect the basic emergence claim. Given that both of these avenues are closed, in what sense are emergent entities real?

Nonreductive physicalists, as well as other emergentists, sometimes identify emergent entities with information. We have already seen this connection between information and top-down causation made by Peacocke. Philosopher of mind David Chalmers (1997) claims that consciousness can be understood in terms of information, invoking a property dualism that falls within a nonreductive physicalist framework. A problem here is that different authors mean different things by the term *information*, some sticking close to a scientific definition as used in information theory and physics, some understanding the term in a broader sense. In order to be compatible with nonreductive physicalism, it would seem that something closer to the scientific sense would be necessary. More generically, we might think of emergent entities as patterns or as a patterned flow. From a nonreductive physicalist point of view, my mind supervenes on my brain, and what is relevant about my brain is its very specific pattern of neurons and neuronal connections along with their associated support networks (glial cells, capillaries) and connections to the body. On the nonreductive account, it is the pattern that is important. In principle, if the pattern of my brain could be reconstructed (for example, if I died but the pattern was saved), I would be conscious once again, or a duplicate of me could be created—with all the attendant identity problems this creates.

This emphasis on pattern is reminiscent of Plato's use of mathematical objects to argue for the existence of a separate world of forms. Just as Plato argued that our knowledge of mathematics and geometric figures revealed an existence prior to this one, connecting us ultimately to the world of forms, so too the emergentist points to the multiple realizability of information-bearing patterns as revealing their nonreducible character. Despite this, the nonreductive physicalist framework has an Aristotelian edge, for it is the shape (the pattern) and the flow of patterns through time (information) that give emergent entities their reality. The pattern is not completely separate from physical reality, as Plato would have it, but is ultimately connected to the physical, as Aristotle seems to imply. These connections suggest that the arguments both for and against Platonic and

Aristotelian forms have some relevance here, although this connection has been poorly explored.

If emergent entities are understood in terms of patterns or information, in what sense are they causally efficacious? Here we have a much larger problem. In invoking top-down causation, nonreductive physicalists have hoped to provide an account of emergent properties that will preserve their causal powers and, in particular, provide space for mental causation and free will when the focus turns to philosophical and theological anthropology (Murphy 1999). Higher-order, emergent entities, therefore, are not only real; they are a cause among causes that need to be taken into account when describing the physical world.

How can this work? Here, the nonreductive physicalist can only appeal to supervenience arguments. As we have already seen, however, there is good reason to believe that these are not going to provide the kind of robust accounts of top-down causation as had been hoped. Nonreductive physicalists are correct to point to the importance of boundary conditions, the influence of the whole on its parts, and the explanatory significance of higher-order entities and laws. But on a nonreductive physicalist account, all of these considerations must be given a nominalist interpretation in reference to causality.

Despite this, there are a few avenues available for the nonreductive physicalist. One avenue suggested recently by Dennett (2003) is to define causality in a way that is going to be relevant only at higher-order levels, not necessarily lower-order ones. Dennett argues that for A to cause B, A must be both necessary and sufficient for B. Necessary and sufficient conditions, to put it as briefly as possible, cannot be given in the attempt to relate prior, micro/subvenient events to later macro/emergent ones. It is thus possible, according to Dennett, for an event to be determined yet, technically speaking, uncaused, providing space for conceptions of mental causation and free will. The form of Dennett's argument, redefining causality, seems to be the primary move available to nonreductive physicalists. One can either define causality differently so as to include top-down causality or one can add kinds of cause (formal cause, structuring cause) to make it plausible. Either way, nonreductive physicalism would seem to entail either epiphenomenalism or, at best, a form of compatibilism with lower-level determinism.

Despite these concerns, emergence within the context of nonreductive physicalism has its place, and there may be many areas where emergence of this sort applies. Computers may, in fact, be the best examples of nonreductive emergence at work. When analyzing how computers operate, we have (in principle) complete knowledge of their lower-level workings and can (again, in principle) connect the lower-level workings with the higher-level structures that emerge. Software programs and computer networks display most if not all of the features of emergent entities, including surprising novelty at the emergent level. For a computer, top-down causation is understandable in terms of supervenience relations, with all that implies.

Radical Emergence. For many advocates of emergence, nonreductive physicalism does not go far enough. In particular, advocates of radical emergence are inclined to reject the central premise of nonreductive physicalism that our knowledge of the physical world is essentially complete and that any new discoveries will not affect our understanding of the world dramatically. Rather, radical emergentists argue, our knowledge of the physical world is incomplete in important ways, and we should be wary of hastily reducing higher-order, complex phenomena into their poorly understood parts.

Radical emergentists share certain strategies with nonreductive physicalists, because both oppose completely reductionist accounts of the world and human beings. Radical emergentists point to the failures of the reductionist program, to stubborn phenomena such as human consciousness that resist attempts at reduction, and to the explanatory gap that results when we try to explain complex systems simply in terms of their lower components.

Radical emergentists differ from nonreductive physicalists in their more expansive understandings of both epistemological and ontological emergence. First, radical emergentists emphasize that our knowledge of the physical world is incomplete, so to claim that human consciousness can be reduced to the activity of neurons or (at the presumably lowest level) a particular arrangement or set of arrangements of subatomic particles is to assert that we already have a complete account of these physical and biological levels. Clearly, we do not yet have complete knowledge of these lower levels, and so, in particular cases such as that of human consciousness, the radical emergentist will argue that it is premature to claim that neurons as we now understand them can serve as the proper subvenient base to provide an account of consciousness, as the nonreductive physicalist will have it. Note what is being argued here. The radical emergentist is not denying that neurons (for example) are necessary for the emergence of human consciousness but is asserting in this case that our current understanding of neurons is deficient in an important way—so important that it prevents us from being able to understand neurons as a subvenient base.

Radical emergence, therefore, has an important epistemological component, which opens up possibilities for more radical ontological claims. Recall that a premise of nonreductive physicalism is that the universe is closed and that the scientific description of the physical world as we now have it is essentially correct. Once this premise is accepted, it follows that any emergent entity must be understood as arising out of the physical world as we now understand it. So, in the case of consciousness, the nonreductive physicalist is pretty much committed to saying that consciousness is a form of information processing arising out of the activities of neurons, because this seems the avenue of interpretation most consistent with contemporary cognitive science. Because radical emergentists do not share the premises of closure and completeness, they are not compelled to make the same move. Indeed, in a difficult case such as consciousness, the radical emergentist may argue not only that we are ignorant of the particular physical basis of consciousness (epistemological emergence) but that there remain important, unknown physical properties that are yet to be discovered (ontological emergence). Radical emergence thus leaves the door open for radical ontological claims in a way that nonreductive physicalism does not.

Implied in this is an understanding of science and reality very different from that held by the nonreductive physicalist. Because nonreductive physicalists are committed to closure and completeness, there is a strong commitment to a unified worldview that is comparatively seamless, emphasizing the smooth flow from the lowest levels of subatomic physics to chemistry, biochemistry, cell structure, multicellular organisms, on up to laws, minds, and the organization of complex societies. The radical emergentist, by contrast, will be more inclined to observe the disunity of science. On this view, there is not a seamless flow from one discipline of scientific study to another. Rather, each level of scientific inquiry should be interpreted as a slice of reality, partially continuous with adjacent slices but partially discontinuous as well. Because of the emphasis on both epistemological and ontological openness, I have referred to radical emergence as open-system emergence (Peterson 2002).

In the theology-and-science dialogue, Philip Clayton has perhaps been the most prominent advocate of a form of radical emergence (1997; 2004). Clayton also distinguishes between reductive, nonreductive, and radical forms of emergence (referred to in Clayton 2004 as *façon de parler* emergence, weak emergence, and strong emergence respectively). Clayton rejects both the reductive and nonreductive forms of emergence in favor of radical (strong) emergence, arguing that radical emergence is required to sufficiently explain consciousness and perhaps other natural phenomena as well. For Clayton, the argument for radical emergence is in no small part an empirical one, arising out of a need to explain the stubborn data generated by the sciences. The reason we come to emergence as a philosophical position, Clayton argues, is that we *observe* emergence in the world and find it to be scientifically useful. For Clayton, human consciousness is one such radically emergent phenomenon, arising out of the natural but not reducible to the physical as understood within the context of contemporary science. Clayton concludes, “Emergent monism makes mental properties strongly emergent out of a substrate that is neither ‘physical’ nor ‘mental’ (2004, 158). On Clayton’s analysis, current neuroscience cannot explain consciousness precisely because neuroscience is not a complete science and as such gives us only a slice of the reality that makes up the human person. Likewise, physics may not be able to explain the complex networks created by brains not because physics is false but because our knowledge of physics is incomplete and, perhaps, limited by the very presuppositions that physics makes.

Another example of the use of radical emergence within the context of the science-theology dialogue is the work of John Haught. Although Haught does not embrace the language of emergence, his approach to science in general and evolutionary biology in particular employs the very kind of arguments typical of radical emergence. In *Deeper than Darwin* Haught provides an extended argument that nature, like a book, can be read on several different levels but also emphasizes the incompleteness of individual levels. In this vein, he argues that the subatomic world that physics describes should be understood not as the concrete, subvenient base out of which everything else arises but as the most *abstract* of the different views of the world that science provides (Haught 2003, 44). Physics provides a slice of reality, but only a slice, implying that higher-order physical realities cannot be simply understood in terms of arrangements of subatomic particles.

A somewhat different approach is taken by Paul Humphreys (1997). Like Clayton and Haught, Humphreys focuses on the incompleteness of the scientific worldview as we now have it, noting that we can never provide an adequate subvenient base because we cannot be sure what the base actually is. While the subatomic world currently described by modern physics may be the ultimate, lowest-level base, tomorrow's new discoveries may render our current understandings obsolete. Humphreys furthermore argues for the possibility of emergent laws and properties that appear only when lower-level entities come together in a particular way. He cites the Pauli exclusion principle as a prime example of this sort of emergence. This principle forbids any two electrons from occupying the same orbital around a nucleus. There is nothing, however, in the basic laws of physics governing single particles to predict or explain why two electrons cannot occupy the same orbital in an atom. The Pauli exclusion principle would appear to be, following Humphreys's analysis, an emergent law that comes into play only when some subatomic particles interact in a particular way. On his analysis, the individual particles do not provide a subvenient base; rather, they are part of a set of conditions necessary for the Pauli exclusion principle to appear.

Other examples may be adduced, either as exemplars of radical emergence or as bearing important family resemblances. William Hasker's emergent dualism (1999), for instance, shares some of the attributes of radical emergence. So do aspects of the metaphysical worldview of process philosophy as enunciated by Whitehead ([1929] 1985). Although the particular routes these thinkers use to arrive at their conclusions are somewhat different, the result is often very similar, if not the same.

EMERGENCE, RELIGION, AND SCIENCE

At this point, the concern over theories of emergence should be clear. An important problem is that when emergence is invoked as an explanatory category, a number of quite distinct claims are actually being made. Generally speaking, most arguments for the existence and nature of emergent entities share seven primary characteristics. Beyond this, however, there is significant disagreement as to how to construe the meaning and significance of emergent entities, ranging from the more reductive approaches of Dennett and Dawkins to the more radical approaches of Clayton and Humphreys, with nonreductive physicalists' accounts occupying a middle position. This diversity is muddied by the fact that some authors seem to be making arguments for more than one kind of emergence while failing to distinguish the kinds of emergence being argued for. Morowitz (2002), for instance, argues for the existence of twenty-eight kinds, or levels, of emergence in the natural world, ranging from the laws governing the origins of the universe to the emergence of social systems and spirituality among human beings, including cells, neurons, and technology. It is not clear, however, that Morowitz's twenty-eight examples are all emergent in the same way, and a good case can be made that they are not. A similar tension (although not explicit contradiction) appears in the recent approach of Ursula Goodenough and Terrence Deacon (2003), who argue that there are three levels of emergence that correspond, roughly, to simple interactions, complex systems, and cognitive systems with memory and feedback. When interpreting the meaning of emergence, they write, "Metabolism and mentality are *nothing but* their constitutional parts. But they are also *something more*, something new and emergent" (2003, 803). So strongly embracing *nothing but* seems to imply the reductionist emergence accounts put forward by Dennett, Dawkins, and others. Yet, the insistence on *something more* seems to imply at minimum a nonreductionist account. Which is being advocated is not clear.

Such conflations seem to be rare, but they illustrate the problems that can arise that in turn create problems for critiques of emergence theories. Critiques that emphasize supervenience relations apply primarily to nonreductionist emergence but not necessarily to radical emergence. Charges that emergence theories are merely a reintroduction of an élan vital or a new kind of dualism apply more to the radical emergentist accounts than to nonreductionist ones.

It is important to note that the three broad kinds of emergence delineated do not necessarily conflict until they are made into universal claims. For example, a radical emergentist may argue that certain kinds of systems are best construed in terms of reductionist emergence (emergent properties are useful fictions), other kinds of systems are best construed in terms of nonreductive physicalist emergence (for example, computer hardware and software), and some few (such as the Pauli exclusion principle or human consciousness) are instances of radical emergence. They come into conflict only when, for instance, the claim is made that all emergent entities are of the nonreductive variety or when there is disagreement over what kind of emergence applies to a particular phenomenon such as human consciousness. In discussing emergence, clarity is precious.

Given these complexities, what is the utility of theories of emergence for theology? If reductionist emergence is taken as a universal account of emergence, it is clearly antithetical to any theological project that makes appeal to the reality of the person and to God, and it is no accident that there is a strong tie between reductionist accounts of emergence and avowed atheism, as the work of both Dawkins and Dennett exemplifies.

Nonreductive emergence presents a more complicated case. It does allow room for the reality of the person and higher-level objects in general but at the price of genuine freedom and causal efficacy. Certainly, nonreductive physicalism has its theological advocates, as exemplified by the work of Murphy, Joel Green, and others (Brown, Murphy, and Maloney 1998; Green 2004). As seen above, however, the idea of mental causation seems problematic at best within a nonreductive physicalist framework, as do claims to human freedom. Murphy claims that nonreductive physicalism is consistent with human freedom, but it would appear that the freedom we are speaking of is the compatibilist rather than the incompatibilist variety. That is, freedom in the nonreductive physicalist context must be compatible with microdeterminism. In addition, because nonreductive physicalism emphasizes causal closure and completeness, God's relationship to the world must be at first blush either completely immanent or completely transcendent. If completely immanent, God is an emergent property of the world as a whole, giving rise to a form of panentheism or, more properly, a panenworldism. An emergent God within the context of nonreductive physicalism would be a God that is determined by the world rather than the reverse (Bielfeldt 2000). The alternative would be to understand God as completely transcendent, with divine action rendered as impossible (deism) or as completely miraculous.

Quantum indeterminacy may solve some of these problems. Robert Kane (1996), for instance, appeals to quantum indeterminacy as a means for supporting a notion of free will that is not bound by microdeterminism. Murphy and others have appealed to quantum indeterminacy as a means of providing an account of divine action compatible with nonreductive physicalism (Murphy 1997). In addition, it is worth pointing out that a significant segment of the Christian tradition, from Augustine through Luther, has endorsed accounts of freedom and predestination that may be seen as compatible with nonreductive physicalism in a way that many current positions are not.

I do not fully evaluate these options here but simply point out that they do have their problems. Quantum indeterminacy does not provide a solution to the problems with top-down causation in a nonreductive physicalist context. Although freedom may be defined in such a way as to be compatible with microdeterminism, I would suggest that stronger accounts of freedom are to be preferred. Beyond this, I also suggest that not only is nonreductive physicalism not good for theology, it is also of limited use for science. With its emphasis on closure and completeness in terms of our contemporary understanding of science, nonreductive physicalism puts a limit on the scientific imagination, a straitjacket that confines interpretation of research into that which is currently conceivable.

At this point radical emergence reveals its strengths. Radical emergence is, arguably, good for both theology and science. It cracks open the world, allowing for the possibility of that which is truly undiscovered. On one hand, radical emergence does not force artificial solutions to existing problems, so there does not need to be, for example, a rush to explain the phenomenon of consciousness in terms of existing scientific categories and models. On the other hand, it does not artificially foreclose scientific investigation the way that, for instance, substance dualism does by proclaiming certain domains (mind, ethics, beauty) as being automatically immune to scientific analysis. Theologically, radical emergence allows for concepts of God that are both transcendent and immanent and provides a better framework for panentheism than nonreductive physicalism.

Nevertheless, radical emergence also has its dangers, possibly leading to what might be called an emergence of the gaps. This is seen most prominently in arguments for the emergence of human consciousness. For many theologians it is sufficient to claim that human consciousness is an emergent phenomenon and leave it at that. This seems to be the route, more or less, that Peacocke takes in his *Theology for a Scientific Age* (1993). While this statement may be satisfactory at the theological level, it is not very informative for the practice of neuroscience and related disciplines. Claims of radical emergence can lead to a disincentive for scientific research, as any insufficiently explainable phenomena can be labeled as emergent and left at that. For radical emergentists, an important question is when to label something as emergent. What makes the Pauli exclusion principle, for example, an emergent law is precisely its inexplicability in terms of lower-level laws and particle interactions. In other words, the evidence for emergence in this sort of case is lack of evidence; a lower-level explanation does not currently exist. Could one exist in the future, so that the Pauli exclusion principle could be reduced to lower-level, more universal regularities? This is a possibility, although the principle has been so thoroughly investigated that such a reductionist solution seems unlikely. There is a disturbing parallel here between radical-emergence arguments and arguments made by advocates of intelligent-design theory that also depend on the lack of evidence for reductionist explanations to defend concepts of irreducible complexity (Behe 1996, for example).

A second issue for radical emergence is whether or not the sciences provide much room for radical-emergence claims. Laws of energy conservation and entropy seem to hold universal sway and must govern any emergent phenomena that are claimed to appear. Although our knowledge of the human brain is far from complete, it is sufficiently detailed to make claims for the emergence of consciousness and human freedom complicated.

There is perhaps no easy way around this. In the absence of any neat algorithm for determining the completeness and strength of scientific theories and their relation to one another, individual judgment with all of its subjective vagaries must be employed. This does not mean that determining emergence relations is an irrational activity, only that it requires a careful and detailed analysis, an openness to revision, and an awareness of when reductionist approaches are promising and when they are not. Indeed, the strength of radical emergence claims comes from the very precise weaknesses of reductionism in specific instances. In this light, it may be better to think of radical emergence not so much as a sweeping ontological claim as a practical heuristic. Radical emergence is a reminder to us all that all is not yet known and that the complexities of experience need to be explained, but not explained away.

NOTE

1. Wacome's article addresses nonreductive physicalism specifically, but his thesis is that nonreductive physicalist accounts offer no advantage over reductionist ones.

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